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# The Evaluation Model of Garbage Classification System Based on AHP

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**ABSTRACT**

**Based on Shenzhen as an example, the questionnaire was designed in advance to get statistical data. In this paper, the AHP and the linear weighted sum method are used for the weight calculation of each factor, obtaining the long-term cost benefit function of the garbage classification system and the garbage classification pattern grading. Finally, we can choose the better garbage classification mode according to this score.**

***Keywords*—** AHP, The Linear Weighted Sum Method, Long-Term Cost Benefit Function

## I. INTRODUCTION

Garbage disposal usually needs huge costs. Therefore, how to choose garbage classification modes for achieving lower costs and higher efficiency is the problem that we must consider. In 2015, Shenzhen put up three new garbage classification modes.

**Model 1:** mixed collection + total incineration + ash landfill + central urban garbage total transfer;

**Model 2:** collect + wet garbage bio-treatment + dry refuse incineration + central urban dry refuse transfer;

**Model 3:** mixed collection + terminal classification + wet garbage biological treatment + dry garbage incineration + central urban dry refuse transfer.

As we all know, there are four main factors affecting long-term cost benefits. They are respectively economic factors environmental factors social factors and management factors. So how to determine these four factors is the core of this problem in the decision-making process. Thus, we introduce the analytic hierarchy process[1](AHP) and the linear weighted sum method[2] to calculate the long-term cost benefit function and choose the better garbage classification further.

## II. CONSTRUCTION OF THE GARBAGE CLASSIFICATION EVALUATION SYSTEM

### *2.1 The Steps of AHP*

- Step1: construct the hierarchy model: goal layer, criterion layer, index layer
- Step2: establish judgment matrix in terms of the relative importance of each index
- Step3: test judgment matrix's consistency and calculate the weight of each factor of criterion layer and index layer.

### *2.2 Construction of the Hierarchy Model*

In this paper, the Shenzhen garbage classification optimization is regarded as the goal layer ( $A$ ) .Economic factors, environmental factors, social factors and management factors are regarded as the criterion layer ( $P_i$ ).And the third is index layer( $M_i$ ),which selects the eight most representative indicators from each criterion layer, as shown in Fig.1.

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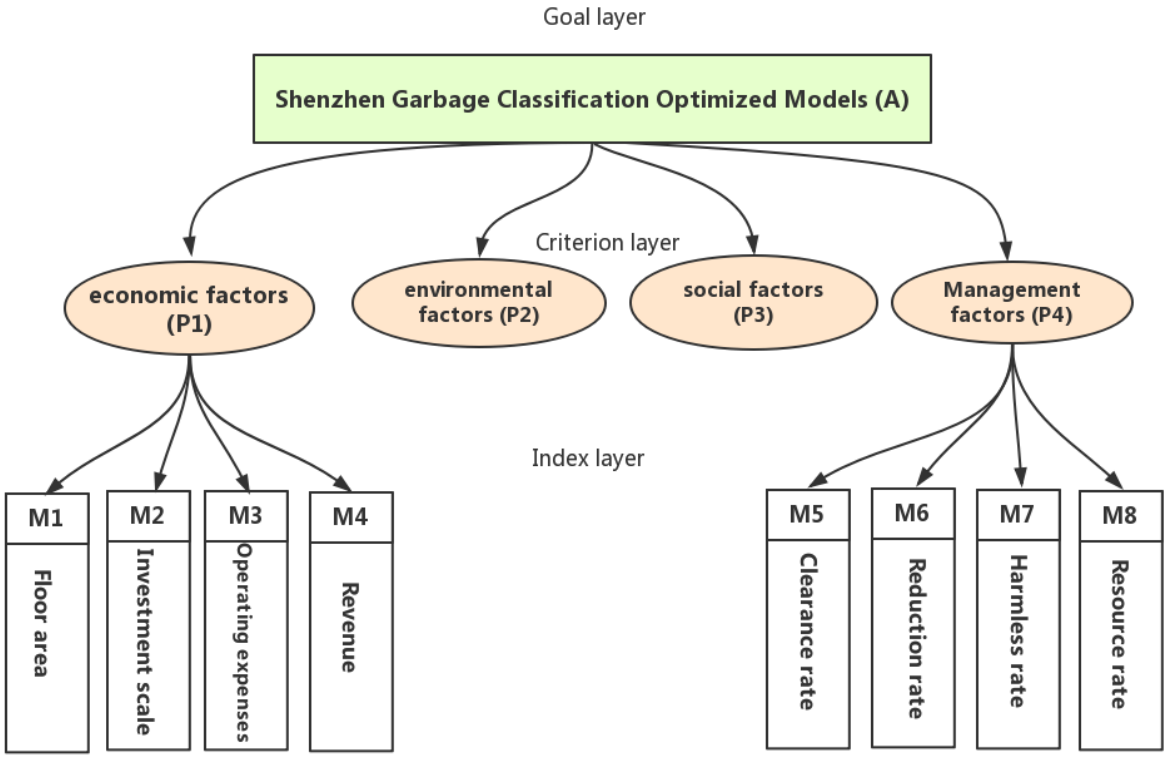


Fig. 1 Ladder hierarchy

**Note:** The eight indicators and data selected in this paper are all from the statistical yearbook of Shenzhen city. And some of the data are calculated by author. In order to calculate conveniently, the author only divides economic and management factors, and environmental factors and social factors are unified.

***2.3 Establishment of Judgment***

The judgment matrix ( $A-P$ ) can be constructed by the proportion of each factor of the criterion layer to the goal layer. Also, so is the judgment matrix ( $P-M$ ). Author randomly selected 70 citizens to score the index layer factors. This score is ten points, as shown in table.1. Based on the results of this survey, judgment matrix can be constructed. According to the calculation of judgment matrix , we can obtain the maximum eigenvalue( $\lambda_{max}$ )and the eigenvector $W = (w_1, w_2 \ldots\ldots, w_n)^T$ ,where the eigenvector is the theoretical weight of each factor. Satisfy suggests we can introduce the number 1-9 and their countdown as the scale[3], as shown in table.2.

Table 1. Standard of grading

| Rank | Very unimportant | unimportant | indifferent | important | Very important |
|---|---|---|---|---|---|
| Score | 2 | 4 | 6 | 8 | 10 |

Table 2. Scale and its meaning

| Scale | Meaning |
|---|---|
| 1 | Compare these two factors, equally important |
| 3 | Compare these two factors, the former slightly more important than another |
| 5 | Compare these two factors, the former more important than another |
| 7 | Compare these two factors, the former very more important than another |
| 9 | Compare these two factors, the former greatly more importantly than another |
| 2,4,6,8 | The median between two adjacent judgments |
| countdown | If $b_{ij} > 0$, $b_{ij} = 1$ |

***2.4 Consistency Test of Judgment Matrix***

To test judgment matrix's consistency, definition:

$$CR = \lambda_{\max} - n / RI(n-1) \quad (1)$$

Generally, if $CR$ is not greater than $0.1$, judgment matrix is regarded as consistent. Otherwise, the judgment matrix should be modified until consistency is demanded.

## III. ESTABLISHMENT OF THE EVALUATION

In terms of the weight of criterion layer and index layer by AHP, the linear weighted sum method can be used to set up a long-term cost benefit function to analyze the comprehensive score situations under different modes.

$$Z = \sum_{i=1}^{n} M_{1i} Z_i \quad (2)$$

$$Z_i = \sum_{j=1}^{n} M_{2ij} N_{2j} \quad (3)$$

***3.1 Calculation of Theoretical Weight***

***3.1.1 Judgment Matrix ( $A-P$ ) between Goal Layer and Criterion Layer***

According to the questionnaire, the significance of criterion layer is as follows:

Environmental factors > Economic factors > Management factors > Social factors. And the scores of these four factors are $2.86, 2.7, 2.09, 1.86$. Therefore, the judgment matrix( $A-P$ ) can be constructed as follows:

Table 3. matrix( $A-P$ )

| $A$ | $P_3$ | $P_2$ | $P_1$ | $P_4$ | $W$ |
|---|---|---|---|---|---|
| $P_3$ | 1 | 1/7 | 1/6 | 1/3 | 0.053 |
| $P_2$ | 7 | 1 | 2 | 5 | 0.5092 |
| $P_1$ | 6 | 1/2 | 1 | 4 | 0.3273 |
| $P_4$ | 3 | 1/5 | 1/4 | 1 | 0.1105 |

Run this matrix under MATLAB, and we can obtain the $CR = 0.0367 < 0.1$. So consistency test can be accepted. Besides, the eigenvector

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$W=(0.053,0.5092,0.3273,0.1105)^T$ .It indicates that the weight of social factors, environmental factors, economic factors and management factors are $0.053,0.5092,0.3273,0.1105$.

***3.1.2 Judgment Matrix ( $A-P$ ) between Criterion Layer and Index Layer***

***Situation 1: Economic Factors***

According to the questionnaire, $M_3>M_2>M_1>M_4$. So the judgment matrix ( $P_1-M$ ) can be constructed as follows:

Table 4. Matrix ( $P_1-M$ )

| $P_1$ | $M_4$ | $M_3$ | $M_2$ | $M_1$ | $W$ |
|---|---|---|---|---|---|
| $M_4$ | 1 | 1/7 | 1/5 | 1/3 | 0.0563 |
| $M_3$ | 7 | 1 | 3 | 5 | 0.5738 |
| $M_2$ | 5 | 1/3 | 1 | 2 | 0.2388 |
| $M_1$ | 3 | 1/5 | 1/2 | 1 | 0.1310 |

Run this matrix under MATLAB, and we can obtain:

$$CR=0.0288<0.1 \quad (4)$$

So consistency test can be accepted. Besides, the eigenvector $W=(0.0563,0.5738,0.2388,0.1310)^T$ . It indicates that the weight of revenue, operating expenses, investment scale and floor area are $0.0563,0.5738,0.2388,0.1310$

***Situation 2: Management Factors***

According to the questionnaire, $M_7>M_8>M_5>M_6$ .So the judgment matrix ( $P_3-M$ ) can be constructed as follows:

Table 5. The judgment matrix( $P_3-M$ )

| $P_3$ | $M_6$ | $M_7$ | $M_8$ | $M_5$ | $W$ |
|---|---|---|---|---|---|
| $M_6$ | 1 | 1/7 | 1/5 | 1/3 | 0.0553 |
| $M_7$ | 7 | 1 | 3 | 5 | 0.5650 |
| $M_8$ | 5 | 1/3 | 1 | 3 | 0.2622 |
| $M_5$ | 3 | 1/5 | 1/3 | 1 | 0.1175 |

Run this matrix under MATLAB, and we can obtain the $CR=0.0433<0.1$, So consistency test can be accepted. Besides, the eigenvector $W=(0.0553,0.5650,0.2622,0.1175)^T$ . It indicates that the weight of reduction rate, harmless rate, resource rate and clearance rate are $0.0553,0.05650,0.2622,0.1175$.

***3.2 Calculation of Long-Term Cost Benefit Function***

Because the environmental factors and social factors are not divided further, we make $Z_2$ and $Z_4$. 10 points uniformly during the process of grading. Finally, by the above data and formula Situation 1 and Situation 2, the long-term cost benefit function can be obtained: $Z=0.3273Z_1+0.053Z_3+6.197$.

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## IV. CONCLUSION

According the above function, the three models' composite scores can be calculated. Because environment factors account for a large proportion in the process of long-term cost benefit analysis, we can adopt Mode 3 in 2017-2021 and Mode 2 after 2021.In this way, the goal of lower costs and higher efficiency can be achieved.

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